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# WHOLE GRAIN CHAPATTI: SHELF LIFE ENHANCEMENT BY VARIOUS TECHNIQUES AND THEIR IMPACT ON QUALITY

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Chapatti is flat unleavened baked product that is prepared from whole wheat flour and is a staple food of Asian people. Freshly baked chapatti is soft, elastic and pliable but when stored at suitable conditions; its texture becomes hard and stales within a day due to high susceptibility of moisture loss. Along with it, fungal growth also makes it unfit for consumption. Shelf life of chapatti is a big issue. To overcome these challenges, different techniques like conventionally baked, preservative addition, partial baked and retort processing used to enhance the shelf life of chapatti. It was concluded that these techniques have great impact on quality and shelf life of chapatti at ambient and freezing storage temperature in order to improving the quality attributes and enhancing the shelf life of chapattis.
**Keyword:** wheat, chapatti, shelf life, preservative, partial baking, retort.

## INTRODUCTION

Cereals and cereal based products are far and widely consumed by humans all over the world and provide a greater amount of carbohydrates, dietary fibers, proteins, vitamins and minerals. Cereal based food products are generally prepared from wheat flour with about 72% extraction rate which outcomes in a low dietary fibre content, vitamins and minerals. The literature dealing with various aspects of the study is briefly reviewed under the following headings:

Cereal and cereal grain nutritional aspects: Agriculture imparts a vital role in Pakistan's economy as in other developing countries. The word 'Cerealis' meaning 'Grain' is a Latin word well-known as a fruit and also called a caryopsis. The cereals are members of the monocot family Poaceae also acknowledged as Gramineae. On a global basis, rice, wheat and maize are the most significant crops, contributing over 50% of the world's cereal production (FAO, 2012). The production of world's cereals grain is over 1 billion tons per annum and deliberated one of the most significant commercial food produces. Cereals supply high starch content, dietary fiber, essential fatty acids, lipids and nutritious protein to us. Foods prepared from cereal grains not only provide carbohydrates but are also good source of energy. Important micronutrients of cereals are minerals, vitamins of B group, antioxidants (thiamine, riboflavin, niacin and pyridoxine) and phytochemicals (Slavin, 2004).

Cereal foods act as "filler" and may help in weight management. Cereal foods are bulky in nature having fiber content and provide no or little energy to body. Fiber normalizes the bowel function and relieves from constipation (Saltzman *et al.*, 2001). It also defined the correspondence between reducing cancer and nutrition such as a food containing whole grains may lessen the risk of cancer by 30 % and has a higher amount of vitamins and minerals (Liu *et al.*, 2003). There is a contrary relationship between the body mass index and consumption of cereal food which means that reduction in body mass index is associated with the increasing consumption of whole grain and at the same time it encourages the weight loss. Hence, due to many positive health effects of cereals take first place in our diet (Rakická *et al.*, 2013).

***Impact of whole grain diet on health*:** Current life style with reduced physical activities has augmented the health problems in both developed and developing countries. Obesity, type-II diabetes and cardiovascular disease are contributory health problems. These risks can be reduced by the consumption of whole grain diets with low glycemic index and high dietary fiber content (Behall *et al.*, 2006). The regular diet from whole grains has significant impact on human nutritional aspects like insulin level, blood lipids profile and micronutrients intake (Jacobs *et al.*, 2002). Over three billion people are micronutrient malnourished (Welch, 2005). The number of life style related disorders is swiftly increasing all over the world. Similarly, the intake of healthy food products such as high fiber, sugar-free and low caloric is escalating in present era. The utilization of foods rich in fiber has been recommended to dazed the health problems such as cardiovascular diseases, hypertension, diabetes and colon cancer (Sudha *et al.*, 2007). However, knowledge about sufficient intake of whole grains and mechanisms by which satisfactory effects are communicated is not clear yet (Slavin,

2003). USDA has announced recommendation for whole grain in its publication to increase the intake of grains in everyday diet (USDA, 2000).

The whole grain comprises of bran (3-30%), a germ fraction (4-17%) and a starchy endosperm (65-75%). The composition of these portions varies according to the type of cereal. Bran is the outermost layer of a grain and containing higher amount of macro and micronutrients including fiber, different minerals and flavonoids. The germ is also rich source of proteins, lipids, B vitamins and vitamin E. The endosperm contains starch mainly amylase and amylopectin and non-starch polysaccharides (Marquart *et al.*, 2002). The whole grains consumption is stated to be related with health benefits, including reduced risk of cardiovascular disease, cancer, diabetes and better regulation of blood glucose level. The health benefits of whole grain products are mostly ascribed due to the presence of bioactive compounds (Edge *et al.*, 2005). Coronary heart disease is the primary reason of death in many developed states and developing countries. Whole grain foods may be individually paying to the cardiovascular defensive properties of fiber-rich foods (Anderson *et al.*, 2000).

Previous researches have recommended that a regular consumption of three servings of whole-wheat grain products is related with a reduced risk of heart disease. However, methodologies for the assessment of whole-grain consumption are changed. This study supports the stated helpful relationship of whole-grain consumption with heart diseases and suggested that the bran constituent of whole grains might be a main issue in this relation (Jensen *et al.*, 2004). The nutritionists recommend that intake of cereal foods on daily basis are for better health instead of single food item (Anjum *et al.*, 2005).

Bakery products are the most consumed foods through the worldwide. There are great differences exist between the types of baked products, raw materials, tradition, processing technologies, and life-style. Bakeries have been responding to the consumers' demands and changes in society, and shift their production processes, products and even distribution channels. Fresh bread as well as other varieties of baked products contained diversified flavors, shapes and sizes. A decade ago, one of the food market drivers was the development of convenience food for satisfying the consumers demand for fresh like products (Caballero *et al.*, 2007).

Consumer's quality awareness of flat breads is generally dogged by health and sensory aspects. Because the increased cognizance of healthy lifestyle, breads containing multigrain, whole grains or other functional components are becoming more vital in the market. The nutritional value of flat bread has been increased by integrating barley, rye and oats into bread formulation (Dewettinck *et al*., 2008).

***Flat bread and types*****:** *Flat bread is the oldest product expected that the numbers of people consuming different flat bread are reached over 1.8 billion. This included the people of south Asia, Middle East, Central America and Southern state of Soviet union where various flat breads are made from different cereals (Qarooni, 1996). Flat bread is famous especially in those areas where bread is used as major supply of calories and dietary protein. There are many kinds of flat breads but variations are in formulation, texture, color, shape and taste in order to enhance the delicacy and quality of these products Flat bread of Middle East is divided into leavened and unleavened bread. Leavened bread included Kamj, barbari, mashrough, tannouri, pita and unleavened included paratha, shark, tortillas and lizzagi (Al-Dmoor, 2012). Examples of unleavened bread are chapatti, parotta, tortilla, pita, yufka, sangak, tandoori roti, balady, taftoon, lavas, barbari, ciabatta, bafla, phulka, baati, kulcha and gyro bread. Flat bread is mostly eaten as freshly baked and prepared both in bakeries and home.*

Almost 80% of this cereal grain is consumed in the form of flat breads locally known *as roti, naan* and *chapatti* (Anjum *et al.*, 2000). In the world, about 65 % of wheat grain is directly utilized by humans while in Pakistan 68-75% of total food consumption comes from this source in daily diet and only 20% of the total wheat produced is used for the production of bakery products (Khan and Shewry, 2009). It fulfills more than half of total regular requirement for riboflavin and iron while it can fulfill the daily requirement of thiamin and niacin. It also ensures economic and feasible provision of carbohydrates and proteins for our regular life. Its dietary value is due to existence of lysine which plays an essential role for its significance (Wahab *et al*., 2007).

***Chapattis:*** *It is unleavened one (single) layer flat bread made from whole-wheat flour is usually consumed immediately after preparation. Chapattis are unleavened flatbreads and formed vital portion of Indian food particularly for those persons who have type-2 diabetes. Flat breads and chapattis are famous and part of regular diet among the members of national minority groups who follow conventional dietary patterns. Chapattis are prepared from whole wheat flour and baked on warm flat plates. Chapattis are rounded in shape having thickness of 3-4 mm and diameter of 10-15cm (Gocmen et al., 2009).*

Freshly baked chapattis are soft, pliable and elastic but on storage they develop hard and brittle texture. Same problem has been observed in case of bread, wherein the crumb becomes hard and dry, followed by crumbliness, harshness and a dry sawdust type taste. Moisture content in freshly baked chapattis differs from 25-35% and the chapatti equilibrates to 88-92% relative humidity. The pH of chapattis differs from 5.8 to 6.0 and decay is typically carried out by moisture loss, molds growth and development of hard texture and stale odour. Primary efforts were done to enhance the shelf life of chapattis with the addition of propionates for arresting mold growth commonly persisted ineffective. A study explained that flour made by mixing of rice, corn,

barley, millet and black gram flour increased nutritional and sensory attributes of the chapattis as compared to whole wheat flour chapattis. Planned actions were required to control the health of hyperglycemic and hypercholesterolemia individuals. Huge population can be easily covered if we consider staple food as a source of supplementation. It was concluded that fibrous food is a vital source that can easily reduce the glucose, cholesterol and triglyceride level in the blood. There is a need to explore the hidden sources of dietary fiber for the improvement of nutritional status of many food products (Butt *et al.*, 2007).

The production of flat bread throughout the world is increasing rapidly: both from commercial mechanical production and traditional production of Middle East breads. Production of Middle East bread needed the selection criteria in flour which affect the shelf life and quality; these included gluten or protein, water absorption, gelatinization of starch, baking conditions and moisture content. With increasing urbanization/ industrialization, researches are striving to provide technologies for development of safe, nutritious acceptable foods as well as making traditional food commercially producible and marketable. Many analysts have tried to enhance nutritive value, cooking properties, organoleptic characteristics and shelf stability of flat bread. Sometimes manufactures use discretionary constituents like yeast fat, skim milk powder and certain additives like enzymes, hydrocolloids, emulsifiers and preservatives for shelf life enhancement and quality improvements (Mir *et al.*, 2014).

Baking is a route that uses a hot plate or an oven to prepare a varied kind of flour-based products. The principal objective is to prepare items that have distinctive aromas, sizes, shapes, colors, flavours and textures. The secondary objective is to enhance the shelf life of product by controlling the moisture content and destroying microorganism and enzymes. There is a vast range of bakery items as a result of mingling a varied range of components and using altered baking conditions and techniques to prepare the different items (Gisslen, 2012).

***Quality parameters for chapatti*:** Chapatti is one of the main foods around the world due to its superior nutritional, sensorial and textural characteristics. However, due to rapidly degrading quality characteristics, shelf-life of chapatti is only a few days at room temperature. Microbial spoilage and staling are the main factors limiting the shelf-life of bakery products. This reveals the importance of studying formulation, processing, packaging, and storage conditions of products (Murat Karaoglu *et al.*, 2005; Galic *et al.*, 2009). Chapatti dough should be extensible, elastic and moderately strong. The chapatti should retain its softness, structure and pleasing color during storage. It must tear smoothly and easily and should not be leathery and brittle. Unless eaten immediately after baking, chapattis became stale and difficult to masticate which poses a problem especially to infants and geriatric (Singh Gujral and Gaur, 2005). The quality characteristics that are acceptable for prepared chapattis are pleasing color, soft texture with chewy nature. During storage, textural changes like loss of extensibility and increased deformation occurs in chapattis. Sometimes due to unsuitable flour type the texture and taste of chapattis are affected that result in hard, non-chewable, fragile and foul tasting product. There is a need to minimize all these problems (Hemalatha *et al.*, 2010).

The review investigates upon the improvement and developments brought about in the realization and storage stability of large-scale production of breads which helped considerably to cater to the increasing demand in the national as well as international markets. The review also indicates the tremendous scope and possible existing's for technical, safety and quality improvements of traditional flat breads (Parimala and Sudha, 2015). Effect of packaging on quality of chapattis

The packaging material is used to prevent the food product against the deteriorative effects of the external environment, communicates with the consumer as a marketing tool, provides the consumer with greater ease of use and time-saving convenience and contains products of various sizes and shapes. Nevertheless, these functions are not totally exclusive; for example, the communication function of the package through warning labels and cooking instructions can also help to enhance food protection and convenience. Although traditional packaging has greatly contributed to the early development of the food distribution systems, so it is no longer sufficient because today's society has become more complex. Innovative packaging with enhanced functions is constantly sought in response to the consumer demands for minimally processed foods with fewer preservatives, increased regulatory requirements, market globalization, concern for food safety and the recent threat of food bioterrorism (Yam *et al.*, 2005).

Bread has a shelf-life of few hours, mostly due to its volume to flat surface ratio. Strengthening caused by drying and staling, is the major factor that affects the shelf-life. Shelf-life enhancement by packaging bread in a high barrier laminate under modified atmosphere of 73% $CO_2$ or 90% $CO_2$ with 27% nitrogen was calculated. A life of fourteen days, as described by bacterial spoilage, was gained for modified atmosphere packaging of bread. Staling, as measured with the help of a penetrometer, was hindered in MAP. Sensory evaluation of MAP bread, against frozen bread from the same lot, gave almost duplicate results. Shelf-life was determined by the presence of microorganisms on bread (Avital and Mannheim, 1988).

The result of packing materials on the acidity and moisture content during storage was determined by ML *et al.* (2011) that Acidity and moisture content value increased during storage, while fat and protein content decreased. Decreased in fat content was due to breakdown of fatty acid into short chain in the presences of enzymes and water content. Flour packed in polythene bags and stored was more stable than flour stored

in tin containers. Chapatti or Missi roti were prepared to enhance the nutritional value with the addition of different flour and stored in tin and polythene bags. Shelf life of samples was assessed by fatty acid acidity and moisture content. During whole period of storage, moisture content was varied from 8.14 to 10.20 in the polythene bags. These values indicated that moisture content was not significantly changed during storage periods and the average mean values were 8.66%, 9.07%, 9.71%, 10.02% at 0, 30, 60, and 90 days, respectively. He also described that multiwall packaging material was the most effective barrier against moisture changes (ML *et al.*, 2011). Flour and Chapatti stored in polythene bags contained lower colony forming unit of mold than the flour stored in tin boxes. Fortified flour chapatti stored in polythene bags contained less mold colony forming units than flour stored in tins. Rheological attributes of wheat flour provide useful information related to the quality of wheat flour, properties needed for design, development of new equipment and textural characteristics of end product. Storage and packaging material significantly affected the rheological property of flour. There was increasing trend in dough development time, water absorption, stability of dough and tolerance index (Huma *et al.*, 2007).

Bakery products lost their quality by loss of staling, mold growth and moisture content. In order to accomplished these factors to cause spoilage or deterioration in bread. Soares *et al.* (2002) used active packaging film. Cellulose acetate films containing different concentration of sodium propionate were prepared. Three pieces of bread were stacked, sandwiched with the prepared film pieces, packed in low-density polyethylene bags and stored for fifteen days at 25 ± 2°C. Treatment without film between the pieces of bread acts as a control. The microbiological analysis indicated that with increasing concentration of propionate into the film decreased mold growth throughout the storage intervals. Bread stored with Cellulose acetate films containing different concentration of sodium propionate displayed a reduction in mold count compared with bread having film without sodium propionate. The pH, moisture content and water activity displayed smaller deviations throughout the storage period (Soares *et al.*, 2002).

***Preservative addition in chapatti:*** Many people do not have facilities of frozen storage and refrigeration to prevent the growth of mold in Arabic bread and hold the bread fresh for more than a few days. Therefore, shelf life enhancement for this type of bread is essential.

Abu-Ghoush *et al.* (2007) uses preservative to increase the shelf life of Arabic bread with the addition of sodium propionate (0.3%, P), fumaric acid (0.2%, F), and sodium propionate-fumaric acid mixture (PF) were used. At 0 day, moisture content among the treatment did not differ significantly although moisture content decreases significantly from 0 to 3 day. Water in bread acted as plasticizer but after 3 day the water content in bread significantly decreased so bread was firmer. So, he concluded that low quantity of water was available to act as plasticizer to retain the bread soft and pliable. The pH of bread for control, P, F and P-F were 5.51, 5.60, 4.27 and 4.77 respectively. These differences in the pH play essential role in determining the color, texture and taste of the product. He concluded that F-P prevent the mold growth 320 time longer compared to control.

Subsequently, a study reported that chapattis can be preserved for six months by incorporating sorbic acid (0.48 per cent) and salt (2 per cent) in the dough and by packing them in paper/Al foil/polyethylene laminate pouches immediately after baking. Despite encouraging results in the laboratory acceptability tests, the chapattis preserved by this method did not receive wide acceptance from the troops mainly because of being slightly bitter after taste. This was found to be related to the sorbic acid concentration in chapattis and became more pronounced during storage. Also, the concentration of sorbic acid in chapattis (0.25 per cent as basis) was higher than the level (0.15 per cent) permitted by P.F.A. Efforts were, therefore, directed towards reducing the concentration of sorbic acid and to improve the flavour and texture of preserved chapattis. Arya reported that effective concentration of sorbic acid for the preservation of chapattis can be reduced from 0.48 to 0.20 per cent by adding citric acid (0.1 per cent) and sugar (3 per cent) along with sorbic acid and by subsequent in pack pasteurization of chapattis at 90°C. Both citric acid and sugar are known to suppress the dissociation of sorbic acid in aqueous solutions. Since only un-dissociated sorbic acid has antifungal action, inclusion of citric acid and sugar in chapattis formula proved highly beneficial in preventing mold spoilage with low levels of sorbic acid (Arya, 1984).

Sharma *et al.* (1995) followed the standardized recipe and method to produce flat breads. She used Indian varieties that are appropriate for bread production. All breads of pleasing flavor and soft textured were produced although different wheat's verities had variable rheological attributes. Calcium propionate (0.5%) and stearyl-2-lactylate (0.5%) were used in breads in order to enhance the quality of breads. Breads were stored at 4 and 37C. Shelf life of flat breads was increased 12 days at 4 C and 8 days at 37 C.

***Effect of preservative on quality of chapatti*:** Chapatti prepared with the addition of additives like liquid shortening, wet gluten, sodium casinate and diastase. Sodium casinate and CMC enhanced the chapatti texture throughout the 24 hours of storage period. According to (Unhale et al., 2012) roti can be preserved up to 6 to 14 days without losing its texture and moisture by the use of ascorbic acid and potassium sorbate. But the high concentration of these had bad impact on the quality of roti.

The TBA value which is a catalog of secondary lipid oxidation was observed during storage periods and radiation processing. Wheat flour at different days of storage had

different value of thiobarbituric acid. TBA value of wheat flour was 0.166, 0.260 and 0.330 at 0, 5, and 8 days of storage. It increased gradually with the increasing storage period. Increasing trends described the deterioration pattern (Khalifa *et al.*, 2015). The effect of antimicrobial additives on quality and aging behavior was assessed. Breads with and without preservatives were par-baked for 10, 15, 20 min at 230ºC. Then breads were wrapped in polythene bags and stored at refrigeration temperature for 7, 14, 21 days. After storage at refrigeration, breads were subjected to softness moisture color analysis and titrability acidity. Addition of preservative has significant effect on moisture content, color, softness and titrability acidity. Moisture content and softness were significantly decreased in bread crust while moisture content, color and titrability acidity of bread crumb significantly increased. After storage, titrability acidity of bread with and without preservative was 2.84 to 2.03 respectively, describing significantly ($P < 0.01$) increased with the addition of preservative. Titrability acidity decreased significantly with the increased of intermediate storage time (Murat Karaoglu *et al.*, 2006).

Calcium-propionate as an antimicrobial preservative in pan baked bread significantly decreased the baking loss, softness and moisture content while color and acidity values significantly increased. Pan baked bread was stored at refrigeration temperature for 7 to 14 days. Without addition of Calcium-propionate samples has titrability acidity 2.24 whereas samples with Calcium propionate addition stored at refrigeration for 0, 7 and 14 days has 2.41, 2.53 and 2.32 acidity respectively (Murat Karaoglu *et al.*, 2005). These studies revealed that addition of preservative have greater impact on the quality attributes of product. Preservatives prevent the products from spoilage by binding water content and breaking the cell structure of microorganism.

Murat prepared chapattis from whole wheat flour with the addition of preservative 'glycerol monostearate' at ratio (0, 0.25 and 0.5% w/w), barley flour (0, 10 and 20% w/w) and sodium chloride (0, 0.5 and 1%w/w). Texture of freshly baked chapatti and after 24 hour of storage was evaluated by objective method that is based on tensile deformation. During storage, deformation modulus and load to rupture increased whereas extensibility decreased. Different levels of preservatives have significantly affected the instrumental texture of chapatti. All three ingredients prevented the chapattis from staling as showed by higher extensibilities values after 24 hours of storage period. During storage of 24 hour, energy to rupture was decreased as compared to freshly baked chapatti from 0.0297 J to 0.0087 J. Energy to rupture of freshly baked chapatti was most significantly affected by the incorporation of GMS. It was increased by incorporation of GMs at level 0.5% in freshly baked chapatti (0.0313J) and in chapatti stored for 24 hour (0.015 J) (Murat Karaoglu *et al.*, 2006).

Additions of hydrocolloids (HPMC, CMC and Guar Guam) at different level have pronounced effect on the freshly baked and stored chapattis. Tear force in fresh chapattis was decreased with the addition of hydrocolloids however addition of guar gum at the rate of 0.75% w/w gave softest texture. Extensibility during storage both at refrigeration and room temperature was decreased but in the case of guar gum there was less loss in extensibility up to duration of 48 hours (Ghodke Shalini and Laxmi, 2007). Chapatti was brittle and hard stored at room temperature for 2 days indicating short distance of extension and high force value before rapture. Tensile test were used to check the effect of hydrocolloid on chapatti stored in refrigeration at room temperature for 2 and 5 days. Most evident changes during storage are related to loss in pliability and extensibility (Ghodke Shalini and Laxmi, 2007).

Gujral and Pathak (2002) studied the effect of additives and composite flour on the texture of chapatti. Parameters like peak force to rupture, modulus of deformation, extensibility and energy to rupture were used to determine the texture of chapatti. He replaced the whole wheat flour with black gram, millets rice, barely and corn. Effect of additives like wet gluten, liquids shortening, skim milk powder, Sodium casinate and diastase and glycerol monosterate was measured. He analyzed that energy to rupture and extensibility decrease upon storage of 24h whereas peak load to rupture and modulus of deformation increased. From studies it was observed that chapatti prepared from composite flour showed higher extensibility even after storage. Some of additives like sodium casinate and wet gluten also significantly enhanced the chapatti texture. Stored chapatti after 24h of was brittle and hard as indicated by high modulus of deformation short distance of extension before rupture and high force values. With the increasing level of wet gluten chapatti remained extensible even after 24h of storage. Gluten increased peak force to rapture but decreased the deformation modulus. Liquid shortening @ 2.2-10% significantly increased the extensibility but with the increasing level of shortening extensibility decreased. Chapatti containing liquid shortening was more extensible at 24h of storage than the control. Glycerol monosterate, CMC and increasing level of sodium casinate significantly increased the extensibility of chapatti than control. Enzymes diastase was also used to delay the staling by the action of starch de-polymerization.

Organoleptic characteristics of the sorghum roti were analyzed at the duration of 3 days. The study was done to check the effect of ascorbic acid and potassium sorbate on organoleptic characteristics of sorghum roti. Sensory score described that there was no considerable difference in flavour, appearance, color and overall acceptability between control and those prepared with the concentration of potassium sorbate 0.5% ($T_1$), 1.0% ($T_2$) and 1.5% ($T_3$) and 100 ppm of ascorbic acid on freshly prepared roti. There was decline in texture, color and appearance of sample containing 0.5% of

potassium sorbate although it shows better taste than the samples $T_2$ and $T_3$. $T_3$ had fair appearance and texture and good color. But taste was adversely effected which displayed the decline in overall acceptability. Though, $T_3$ sample had the longest shelf life as compared to others. Result revealed that ascorbic acid addition did not affect the sensory characteristics but the gradual increase of Potassium sorbate increased the shelf life of roti but overall acceptability of the product declined due to adverse effect of taste.

***Partial baking method:*** Partial baking is bread making techniques comprising two steps of baking with an intermediary freezing stage. Firstly, the proofed dough parts are baked on hot plate into partially baked products with extreme moisture holding and the least crust coloration (Hebeda, 1996). Secondly, the products are cooled to the room temperature, quickly freezing by conventional blast freezing, packed and kept till the last re-baking at the point of trade. Par-baking has a pronounced market prospective since the process offers chance to supply fresh baked bread with a modest baking step at trade locations. The core objective of offering par-baked breads to consumers is to facilitate all day availability of fresh breads.

Shelf life of chapattis can be increased by partial baking that is two step methods. (Yadav *et al.*, 2009) studied that extensibility of partial baked chapatti was more than conventional when stored at frozen temperature and retro gradation enthalpy was higher in conventional and partial baked chapatti when stored at ambient temperature.

***Effect of freezing or partial baking on the quality of chapatti:*** Work was done to determine the effect of frozen texture and prebaking on the texture of bread. Texture was determined with the help of instrumental texture profile analyzer. Hardness of bread during 1, 3, 5 and 7$^{th}$ week was 12.20, 13.55, 12.16 and 12.97 respectively. Cohesiveness and springiness decreased during the storage (Fik et al., 2002). Ready to bake frozen chapattis were baked and subjected to textural profile analysis. It was interesting that hardness level increased significantly up to fourth frozen thaw cycle afterward it showed the decreasing style. But glycerol and GMS added shoed less increase in hardness value.it was observed that after 4$^{th}$ cycle of freeze thaw control chapatti was brittle as compared to glycerol and GMS added ones. Brittleness is not a desired characteristic. All other textural attributes like chewiness, springiness and cohesiveness decreased significantly after each freeze taw cycle but reduction was significantly more in control as compared with GMS and glycerol added ones (Yadav et al., 2009)**.**

Gujral *et al.* (2008) prepared chapatti to check the effect of storage on the texture of partial and conventional baking using tensile deformation and DSC for retro gradation studies. Extensibility of conventionally baked chapatti was decreased by 20.15% and 58.7% respectively at frozen and ambient temperature after 24 hour of storage. But the partial baked chapatti showed much lower decreasing behavior (0.01% and 3.7%) in extensibility when stored at frozen and ambient temperature higher retro gradation effect was measured in both conventional and partially baked chapatti those were stored at ambient temperature than their counterparts kept at -18$^0$C. Increasing extensibility behavior was observed in the partial baked chapatti stored for extended period of freezing. Extended frozen storage did not affect the extensibility of conventional baked chapatti. Frozen partially baked chapattis after thawing and re-baking showed texture of chapatti corresponding to that of conventionally baked chapattis. Therefore, there would be reflected a better choice than frozen conventionally baked chapattis for retarding staling. Freshly baked chapatti that was prepared by using conventional method was pliable, soft and extensible because it had low modulus of deformation 0.38 MPa, low peak force 1.6 N and longer distance of rapture 10.37 mm. Difference in tensile deformation modulus of partial baked and conventionally baked chapatti was due to difference in the moisture content of both chapattis at different storage temperature. Energy to rapture of samples increased when samples were stored at ambient temperature for 24h of storage. Extensibility of wheat flour chapatti was decreased after 24h of storage at ambient temperature due to staling.

Sensory parameters partially baked chapattis were significantly affected by every freeze thaw cycle. More than 7 sensory score was considered to be acceptable Maximus score was observed in case of texture (8.0), mouth feel (8.0) and overall acceptability (8.0) in case of glycerol addition that is significantly higher than GMS and control. During every freeze taw cycle, Sensory score for texture gradually decreased but in case of instrumental texture data, there was increase in hardness up to 4$^{th}$ cycle in all samples followed by sudden decrease. This concluded that chapattis for better acceptability should have chewiness between 0.85 and 2.2 Nmm and hardness 3.9 and 4.4 N (Yadav *et al.*, 2008).

Storage of frozen partial baked breads for longer periods results in product deterioration such as such as flavor, moisture and firmness losses. Different variety of Partial baked breads were stored at -18$^o$C for 9 months (Vulicevic *et al.*, 2004) and changes in physical, chemical and sensory attributes were evaluated during storage. Moisture of crumb and crust, mouth feel and springiness were the most sensitive quality parameters that were significantly declined after fourth week of storage. Textural (sensory parameter) of bread decreased at various rate at different storage time. Slow changes in texture at first phase and rapid degradation in secondary phase were observed. Some Color parameters were significantly affected with the storage time. Changes in crust color are not only important for visual observation, but also relates to bread crispiness. Results showed the changing in quality and sensory parameters during storage. But it was accepted by the sensory panel because it had better correlation with sensory and quality parameters (Vulicevic *et al.*, 2004).

***Retort packaging and effect of retort processing on the quality of chapatti:*** Radiation processing method was used to prepare ready to eat methi-paratha that is flat unleavened bread. Products were vaccum packed and stored in frozen condition. Lipid oxidations of samples were evaluated during the storage. Thiobarbituric acid value did not express any significant increase with time. But there was slight increase in thiobarbituric acid value with the increasing storage. This could be explained to fact that all samples were vaccum packed and irritated. Both these factors minimized the effect of oxidation (Bhoir et al., 2015)**.**

Thiobarbituric acid vale of chapatti were significantly increased from 0.086 to 0.121 mg MA/Kg after the 12 month of storage period that may be due to breakdown of long chain fatty acid in to short chain fatty acid. Texture analyzer was used to determine the texture of spinach chapatti at initially and regular interval of storage period. Different parameters like cohesiveness, springiness, chewiness and hardness were studied. It was observed that hardness increased from 6.54 to 18.16N after $12^{th}$ days of storage. Cohesiveness and chewiness significantly increased from 0.126 to 0.293 N and 0.90 to 2.12 Nmm respectively after the 12 month of storage period. These changes are linked with the loss in solubility of starch and increase of crystalline that lead to brittle and hard texture of stored chapatti. But during storage, springiness that is elastic property of the product was significantly ($p \leq 0.05$) decreased from 1.10 to 0.40 nm (Khan *et al.*, 2013). Kotturi and Kannampilly (2013) prepared the retort processed partially baked chapatti and unprocessed partially baked chapatti stored at ambient temperature. Sensory evaluation of chapatti was done at different interval of storage. Different parameter like taste, aroma, color, texture and overall acceptability were determined. Throughout the whole period of storage, retort processed partially baked chapatti remained stable at ambient temperature. Overall acceptability of the product decreased from 9.2 to 8.08 during the storage period from 0 to 8 weeks. Various concentration of spinach paste were used for preparing of retort processed chapatti by keeping other ingredients constant and assessed for sensory characteristics by a semi trained panel to check the acceptability. Chapatti recording highest in sensory characteristics like taste, color and texture was taken standardized for preparation of conserved chapatti. During storage at ambient temperature, different physiochemical changes were measured. No significant changes in moisture content were observed because it is reported that aluminum foil has good barrier ability against light, microorganism and mass transfer. Thus, on the completion of storage studies, moisture content of the product was retained (Brody *et al.*, 2001).

Sensory statistics for retort processed chapatti was determined by using 9 hedonic scale and unacceptable rejection limit of product was taken below 7 score. Based on the above criterion, samples remained acceptable and stable throughout the whole period of storage. Overall acceptability of the product decreased from 8.5 to 7.1 through the whole period of storage at ambient temperature. L* and B* values decreased and a* value increased significantly. Chapatti becomes darker and sample redness has been changed during storage (Tosun, 2004; Semwal, 2011) but chapattis remained microbiologically safe through whole period of storage. Sensory assessment of thermally processed chapattis were done by using 9 points hedonic scale and 7 score on hedonic scale was considered as unacceptable point. By using this criterion samples remained acceptable and stable throughout the whole period of storage. The total acceptability score of chapattis declined from 8.5 to 7.2 during storage. Microbiological data of thermally processed chapattis showed that there were no standard plat count and yeast and molds during the whole period of storage.

## MICROBIOLOGICAL STUDIES

Microbial load is an important determinant indicative of quality of any food product. Every step in handling and preparation of food may be a potential source of contamination. In the course of three months of storage, vacuum packaged and ordinary healed sealed malted composite flour chapatti were examined for the presence of total viable organisms and yeast and molds at monthly intervals. During the entire storage period, the enumerated values of TVC and Y & M counts i.e. 0 to 5200 CFU/g and 0 to 122 CFU/g, respectively for both packaged (vacuum and ordinary heat sealed) chapatti are much lower than the wheat flour specification given by Kenya standard, (2009) of maximum permissible level of TVC ($10^5$ per gram) and Y& M count ($10^4$ per gram). In the present study, Munasinghe *et al.* (2013) prepared a composite flour of mung beans, soybean and brown rice. They also reported nil detection of coliform count in the composite flour while TVC was quite higher than the present study i.e. 2.75×106. . Similar to the findings of past study, Compaore *et al.* (2011) observed nil growth of harmful microbes in pearl millet and maize based complementary flours. Further, comparable findings were observed by Ojure and Quadri (2012) regarding the microbial flora of plantain flour. It was reported that the TVC and Y& M counts were found to be 2.1 $x10^2$cfu/g 1.1 x $10^2$ and CFU/g, respectively as described by Baranwal *et al.* (2014).

According to Unhale *et al.* (2012) roti can be preserved up to 6 to 14 days without losing its texture and moisture by the use of ascorbic acid and potassium sorbate. But the high concentration of these had bad impact on the quality of roti. Pour plate technique was used to check the microbial quality of sorghum roti. Roti prepared with addition of different concentration of potassium sorbate while keeping constant concentration of ascorbic acid. Result showed that on the $3^{rd}$ days mold growth was present on control samples whereas TPC and Y & M growth appeared on 6 and 18 days at $T_1$

(0.5%) and $T_2$ (1%) respectively. Sample $T_3$ (1.5%) was in good condition up to 18 day because higher concentration of potassium sorbate was used. Bacterial growth was in increasing order but after this this trend was decreasing as per WHO (1994) yeast and molds and total plate count should be less than $1 \times 10^4$ and $2 \times 10^5$per gram respectively.

Another study during first week of storage, there were no mesophillic aerobes and yeast & molds in thermally retort processed chapatti. Growth of microbes and yeast & molds remained within the limits till 8 week of storage in thermally retort processed chapatti but its limits exceeded ie.$3\times10^{-2}$during the 9th week of storage. Study demonstrated that thermally processed chapatti were microbiological safe throughout the 8th week of storage at ambient temperature. Mesophillic and yeast and mold in unprocessed chapatti remained within limits on 1st day but it mesophillic count exceeded from limits on 3rd day i.e. $17 \times 10^2$ in addition samples also showed the yeast and mold growth which indicates that unprocessed chapatti were microbiological unfit for consumption on 3rd day but it was safe only for 2 days (Ranganna, 1986).

Chapatti remained microbiologically safe throughout the 12 months of storage. During the entire period of storage, total plate count of freshly baked chapatti and stored chapatti remained within the limit. There were no yeast and mold cunt in freshly baked chapatti and as well as in the stored chapatti which ensured the adequacy of the process and its fitness for human consumption. There was experimentally no changes occurred in microbiological status of freshly baked and stored chapatti during the whole period of the storage (Khan *et al.*, 2013).

***Conclusion:*** Study revealed that application of different techniques has positive impact on shelf life of chapatti. So shelf life of soft and pliable chapatti can be increased by using partial baking, retort processing and with the addition of prescribed amount of preservative. It was concluded that using these techniques qualitative, microbiological and sensorial parameters of chapatti remained in safe limit through respective period of storage**.**

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